CONCISE REPORT

A modification of the Omeract RA MRI score for erosions for use with an extremity MRI system with reduced field of view

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Objectives: To develop and test the reliability of a modified version of the OMERACT rheumatoid arthritis magnetic resonance imaging score (RAMRIS) for erosions using extremity MRI (eMRI) with reduced field of view (RAMRIS-RV).

Methods: Using a MagneVu 0.2 T machine, the preliminary RAMRIS-RV assessed erosions in metacarpophalangeal (MCP) joints 2–3, bases of metacarpal (MC) 2–5, and all wrist bones excluding base MC 1, pisiform and trapezium. T1 weighted images of ⩾500 MCP and wrist bony sites from a mixed severity RA and control cohort were evaluated. An inter-reader reliability study evaluating 300 wrist and 160 MCP bony sites was then performed.

Results: Mean per cent exact (and close) agreement results were as follows: MCP proximal sites 83.5 (96.2), MCP distal 54.4 (77.2), bases MC 2–4 85.2 (96.7), carpal bones 79.0 (92.1), distal radius/ulna 66.4 (87.8). The base of MCP 5 was visualised in ⩽50% cases (13/25) and was removed from the final RAMRIS-RV.

Conclusions: The RAMRIS-RV is a practical tool that can be used with eMRI with a reduced field of view. This study shows excellent inter-reader reliability for erosion assessment, albeit in a reduced number of bony sites.

Magnetic resonance imaging (MRI) has become increasingly recognised as a validated outcome measure for evaluating rheumatoid arthritis (RA).[1] In terms of bone damage evaluation, the tomographic nature of MRI provides a significant improvement in sensitivity for erosion detection, as evidenced by recent studies comparing computed tomography, MRI and conventional radiographs.[2–4]

Extremity-MRI (eMRI) machines have been developed primarily for use in the outpatient clinic setting. Such machines have modest space requirements with only the extremity of interest needing to be placed inside the machine, enhancing patient acceptance, reducing cost and increasing availability.[5] While these provide valuable alternatives to high field machines, there are some significant trade-offs. For example, since most of the machines use a smaller magnet strength, this results in a degree of compromise for image clarity as well as limitations in the field of view (FOV).

In order to use MRI as an outcome measure in a reliable and validated form, the MRI Inflammatory Arthritis Task Force of the Outcome Measures in RA Clinical Trials group (OMERACT) has developed the RA MRI score (RAMRIS) which is presented in the EULAR-OMERACT Image Reference Atlas[6] and has been subsequently validated.[7–9] However, the application of the RAMRIS to all eMRI machine images may be limited, as it was developed using images that evaluated all the metacarpophalangeal (MCP) joints and/or the entire carpus.

The primary objective of this work was to develop a modified version of the RAMRIS scoring system—the RAMRIS-RV (Restricted field of View)—which could be used to score erosions on images produced by eMRI machines with a restricted field of view. The performance of the RAMRIS-RV was then assessed by an inter-reader reliability study and final modifications to the scoring system made.

METHODS

Ethical approval was granted by local ethics committees in the 2 international centres involved in this work. T1 weighted images were acquired with a 3-dimensional sequence (allowing reconstruction in other planes) using a MagneVu MV1000 0.2 T machine (MagneVu, Carlsbad, CA). The imaging specifications were as follows: T1 weighted spin echo (TR/TE, 100/27 ms; field of view 50×75 mm×15 mm; 2 excitations; 0.625 mm individual slice thickness (Z plane), 1 mm coronal (X and Y inplane) resolution. Separate acquisitions were required for the MCP 2–3 and carpal images, respectively. No intravenous contrast was used.

Preliminary work involved the evaluation of more than 500 MCP (proximal and distal, second and third MCP joints) and wrist (base of metacarpals 1–5, carpal bones, distal radius and ulna) bony sites to assess which sites were frequently visualised by the MV1000 machine. Following application of the RAMRIS to these images, the base of metacarpal 1, pisiform and trapezium were excluded from the RAMRIS scoring template as they were rarely visualised. The resultant scoring system was the preliminary RAMRIS-RV. RAMRIS-RV differed from RAMRIS in the reduced number of bony sites examined and that only erosions are examined, thus removing the need for intravenous contrast.

To assess this RAMRIS-RV, an inter-reader reliability study was then carried out. A total of 160 second and third MCP and 300 wrist relevant bony sites were selected from patient images representing a spectrum of normal to severely damaged joints. The cohorts chosen were healthy volunteers (MCP sites 40, wrist sites 120), early RA patients (MCP sites 88, wrist sites 60) through to established RA (MCP sites 32, wrist sites 120). The early RA cohort had a median disease duration of 7.5 months, and the established RA cohort a median disease duration of 7 years.

The OMERACT definition of an MRI erosion describes a sharply marginated bone lesion, with correct juxta-articular localisation and typical signal characteristics, with a cortical break and which is visible in two adjacent planes.[6] Although the imaging acquisition with the MagneVu is 3-dimensional, the coronal images have the best clarity, and so we modified the last part of this definition for the RAMRIS-RV, such that an erosion was required to be visible in 2 adjacent coronal slices (in addition to the 2 planes stipulated by RAMRIS) in order to increase reliability for erosion detection. The erosions were scored 0–10 (according to RAMRIS) based on the proportion of

Abbreviations: eMRI, extremity magnetic resonance imaging; FOV, field of view; MC, metacarpal; MCP, metacarpophalangeal; MRI, magnetic resonance imaging; OMERACT, Outcome Measures in RA Clinical Trials; RA, rheumatoid arthritis; RAMRIS, rheumatoid arthritis magnetic resonance imaging score; RAMRIS-RV, rheumatoid arthritis magnetic resonance imaging score for extremity MRI with reduced field of view

Figure 1 3rd MCP proximal joint erosion.

Figure 2 Multiple carpal bone erosions.

eroded bone compared with the ''assessed bone volume'' judged on all available images, where 0 denotes no erosion, 1 denotes 1–10% of bone eroded, 2 denotes 11–20% and so on. For long bones, the ''assessed bone volume'' was assessed from the articular surface (or its best estimated position if absent) to a depth of 1 cm, while in carpal bones it was the whole bone. A fused bone scored 10. A ''not scorable'' image was defined as due to either motion artefact or the joint area having not been imaged (either partially or completely).

The images were scored by 2 experienced readers from different international centres (EO, PGC). The scorers were blinded to the patients' diagnoses. The images were scored using a viewing panel of 3×3 coronal view images, using the ''stack'' view to visualise sagittal and axial planes.

For each joint site scored, percentage exact (where the 2 scorers agreed exactly), close (where the 2 scorers differed by 1) and agreement on damage (where the scores were dichotomised as no damage (score 0) versus damage (score of 1–10) scores were calculated.

RESULTS

A total of 158 of 160 MCP sites and 260 of 300 wrist bone sites were agreed scorable by both readers. The mean percentage exact (and close) agreement results were as follows: MCP proximal sites 83.5% (96.2%), MCP distal 54.4% (77.2%), bases metacarpals 2–4 85.2% (96.7%), carpal bones 79.0% (92.1%), distal radius/ulna 66.4% (87.8%). Analysis of the 3 separate sub-groups (healthy volunteers, early RA, established RA) showed percentage close agreement results of 100.0%, 80.2% and 87.5%, respectively, for the MCP sites and 94.9%, 100.0% and 86.6%, respectively for the wrist sites. The overall results for the MCP, MCP bases and wrist bones are shown in table 1. Examples of erosions are shown in figs 1 and 2.

The base of MCP 5 was removed from the final RAMRIS-RV score, as it was visualised in less than 50% of the images scored. The ranges of RAMRIS-RV sum scores for erosions of unilateral second and third MCP joints, wrist and both are 0–40, 0–110 and 0–150, respectively.

DISCUSSION

The use of eMRI machines is increasing because of greater access, affordability and patient tolerance. In Europe, the Esaote C scan is particularly popular, and in the USA the MagneVu MV1000. There are, however, important differences between machines that need to be highlighted. The limitation in terms of FOV depends on the machine manufacturer: for example, in one acquisition, the MagneVu MV1000 can only scan 2 metacarpophalangeal (MCP) joints or 1 incomplete carpus, whereas the Esaote C scan is capable of imaging 1–5 MCP joints or a wider view of the carpus (eg, including the distal radio-ulnar joint). Because of the reduced FOV, the MV1000 machine is at a disadvantage when compared with other eMRI machines such as the C scan. There are also operational differences such as liquid nitrogen cooling required by the MV1000 but not the C scan. Neither machine requires additional shielding or a dedicated power supply, thus allowing them to be sited in a suitable clinic room.

Use of the RAMRIS as a scoring method for eMRI machines with a reduced FOV is not possible because of the reduction in bony sites that are visualised. Because the MV1000 machine has the smallest FOV of the eMRI machines currently available, the scoring system has been tailored accordingly. Sites omitted from the RAMRIS to produce the RAMRIS-RV were MCP joints 3–4 (proximal and distal), the bases of metacarpals 1 and 5, pisiform and trapezium. Excluding these bony sites (4 in the MCPs and 4 in the wrist) in this modified RAMRIS has the

Table 1 Inter-reader reliability results using RAMRIS-RV

	MCP2 proximal	MCP2 distal	MCP3 proximal	MCP3 distal	Base MCP2	Base MCP3	Base MCP4	Base MCP5	Capitate	Distal radius	Distal ulna	Hamate	Lunate	Scaphoid	Trapezoid	Triquetrum
Total no. of scorable sites	39	39	40	40	17	25	24	13	25	23	19	25	25	20	20	24
Percentage exact agreement	76.9	51.3	90.0	57.5	88.2	80.0	87.5	100.0	72.0	69.6	63.2	88.0	60.0	85.0	90.0	79.2
Percentage close agreement	92.3	76.9	100.0	77.5	94.1	96.0	100.0	100.0	88.0	91.3	84.2	96.0	92.0	95.0	90.0	91.7
Percentage agreement on damage	76.9	69.2	90.0	77.5	100.0	88.2	80.0	87.5	80.0	82.6	89.5	92.0	72.0	90.0	95.0	87.5

potential to reduce the information available compared with traditional RAMRIS used with a wider FOV. This modification of the traditional scoring method due to poorly imaged sites, however, is not a new phenomenon in developing scoring systems for RA. A similar process was utilised in the creation of the Sharp scoring system for radiography, where certain areas of the carpus were not adequately seen on plain film.[10] The original RAMRIS can, however, be used on images obtained on other eMRI machines (such as the Esaote). We included only second and third MCP joints in the RAMRIS-RV, as these are known to be the most frequently affected MCP joints and to enhance clinical utility by reducing scanning time; all 4 joints could be included if time were not a consideration. Clearly, further study will be required to examine if a reduction in bony sites results in reduced sensitivity to change over time.

Synovitis and bone oedema were not assessed in this study, the latter because of known limitations of eMRI to identify bone oedema.[11] The validity of evaluating these features using the MV1000 has not yet been reported and would require a comparison with high field MRI. It is certainly unlikely, given the known reduced sensitivity of eMRI (Esaote C scan) for bone oedema that such a scoring method for this would be useful. In clinical practice, it is very unlikely that intravenous gadolinium (the gold standard for assessing synovitis) would be used routinely, so there would be limited value in developing a scoring method for this.

Other limitations of the RAMRIS-RV centre around intrinsic limitations of low field eMRI and in particular those with a reduced FOV. These include the inability to visualise all joint areas, small changes in positioning affecting the joint sites visualised and artefacts caused by the inhomogeneity of the magnetic field. The MagneVu images have a much higher spatial resolution than that used for typical hand and MRI examinations, and so the bony cortices can appear irregular and even mimic erosions.[12] In addition, motion artefact can occur with any type of MRI machine and can affect picture quality leading to scoring difficulties. This study has also not addressed issues of construct validity by comparison of bone erosions and damage between high field and eMRI.

In summary, the RAMRIS-RV—a practical version of the RAMRIS—which was developed and tested in this study allows systematic assessment of images for erosions. Such assessment can be repeated in a consistent and reliable way for use in clinical trials when eMRI with a limited FOV is used. This study shows excellent inter-reader reliability using the RAMRIS-RV, albeit in a reduced number of bony sites, and can be considered as a reliable method of assessing eMRI images.

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